



Statement paper

Evidence-based recommendations on automated external defibrillator training for children and young people in Flanders-Belgium

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ABSTRACT

Objective: The aim of the study was to identify the most relevant literature on skills, attitude and behaviour of children and young people towards the use of an automated external defibrillator (AED) and then develop recommendations according to the principles of evidence-based practice. These recommendations were to serve as a basis for educational materials which would ensure that the implementation of AED-training within schools and youth organisations would be a simple process.

Methods: A systematic literature search was performed using a specific research question: "Are children of different ages able/willing to use an AED after a training compared to another/no training?". A guideline development panel meeting was organised to formulate practice guidelines. The panel consisted of experts from different fields (medicine, education and psychology) and representatives of the end users (teachers and youth leaders).

Results: The systematic literature search identified five studies concerning AED skills by children and young people, and two studies concerning the attitudes and behaviour of children and young people towards the use of an AED. The guideline development panel carefully examined the available scientific evidence, took into consideration the skills and attitudes of children and young people, including the psychological consequences of managing a potentially life-saving situation and formulated evidence-based recommendations and good practice points.

Conclusion: Based on these recommendations, an education programme and new educational materials have been developed by the Belgian Red Cross-Flanders. In this way school staff and youth leaders are properly supported to teach first aid techniques to children and young people (6–18 years).

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1. Introduction

Sudden cardiac arrest (SCA) is one of the leading causes of natural death in high-income countries.^{1,2} Every year in Belgium, around 10,000 people die from SCA with most of these events occurring outside of the hospital. It has been shown in multiple studies that quick initiation of cardiopulmonary resuscitation (CPR) and defibrillation is correlated with higher chances of survival.^{3–9} Timely initiation of defibrillation can only be achieved by involving laypersons during the first minutes after sudden cardiac arrest. Therefore, it is of great importance to (a) train laypersons in the use of automated external defibrillators (AED's), and in addition to

(b) make AEDs widely available in public places. Publicly accessible AED's are designed to be easy- and ready-to-use, i.e. once turned on, the AED gives step-by-step spoken instructions. The device will: (1) instruct how to place AED pads, (2) analyse the heart rhythm, (3) ask those nearby to stand clear of the patient and (4) direct to press the shock button if appropriate. In this way, AED's can not only be utilised by healthcare professionals but also by lay rescuers with little training to help people with SCA.^{10–12}

Although AED's are already accessible at various public locations, The European Resuscitation Council recommends to have more AED's in public places (such as airports, train stations, sports arenas, schools, and town halls) to provide greater access and to develop AED programmes.^{13,14} Increased access to defibrillation devices increases their availability to a broader public, including children and young people. Consequently, children and young people are an important subpopulation that can potentially play an important role in bystander delivered defibrillation, thus

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contributing to a shortened response time in case of SCA and increasing the likelihood of survival.

On the 21st of September in 2006, the Belgian government enacted a law (Belgisch Staatsblad – 21 September 2006), declaring that everyone may use a fully automatic AED in case of a SCA, including children and young people, without legal consequences. In other words, the Belgian government supports and encourages the use of AED's by laypersons, including children and young people. However, a recent population-based survey in Belgium¹⁵ indicated that less than 50% of the participants ($n = 613$) knew what the function of an AED was. Therefore, a wider dissemination of AED training for those who are more likely to use AED's in public places, might effectively increase the proportion of bystanders likely to use an AED to defibrillate. Through education and training, school-based AED programmes may lead to improved knowledge of defibrillators as well as of the ability to recognise the main symptoms of sudden cardiac arrest.

As well as advocating the placement of more public-access AED's, the Belgian Red Cross-Flanders (BRC-F) emphasises the importance of public defibrillation by acknowledging municipalities, companies, schools and organisations with the 'Hartveilig' (Eng. 'Heart-safe') label if they have installed an AED and organised resuscitation trainings (www.hartveilig.be). Additionally, BRC-F actively encourages the public to enrol into AED training courses.

Because the Belgian Red Cross-Flanders wants to support its activities in an evidence-based way, the Centre for Evidence-Based Practice of the BRC-F develops evidence-based recommendations as a basis for these activities. The goal of the development of evidence-based first aid guidelines is to make first aid education more effective. This paper describes the process used to develop an evidence-based guideline on education of the first aid technique "Use of an AED by children and young people". The objective was to combine information from an evidence summary, with practical experience and expert opinion, to develop evidence-based recommendations. These recommendations would then form the basis for the development of a study programme and educational materials geared towards children and young people of different ages. The analysis focused on the following questions:

- (a) Can children and young people of different age groups be effectively taught to use an AED?
- (b) What are the factors that influence attitudes and behaviour of children and young people regarding the use of an AED in case of sudden cardiac arrest?

2. Methods

Questions related to AED training for children and young people were initially posed by the Red Cross Youth Department. From there, two 'PICO' questions were developed, taking into consideration the Population (P), Intervention (I), Comparison (C) and Outcome (O):

1. Are children of different ages (P) able to use an AED (O) after a training (I) compared to another training/before training (C)?
2. Are children of different ages (P) willing to use an AED (O) after a training (I) compared to another training/before training (C)?

For the development of guidelines, the BRC-F makes use of the AGREE II principles. Therefore, following steps were undertaken.

2.1. Search strategy

A comprehensive systematic literature search was conducted whereby relevant evidence was identified using the following

electronic database search engines: The Cochrane Library, MEDLINE (via PubMed interface) and Embase (via Embase.com interface). Articles were included from the date of inception of the databases until the end of December 2011. The search strategy comprised of 3 parts: ('resuscitation' OR 'first aid' OR 'defibrillators') AND ('child' OR adolescent' OR 'young adult') AND ('education'). Index terms were used to ensure the search was as thorough as possible. The reference lists of all retrieved papers were searched manually (TD).

2.2. Inclusion and exclusion criteria

Studies were eligible for inclusion if they met the following criteria:

Population: studies with children or young people (max 18 years).

Intervention: studies on AED use or training.

Outcome: studies measuring following primary outcomes: performance and skills in use of an AED; attitudes towards the use of an AED.

Study designs: experimental or observational studies; practice guidelines and systematic reviews were used as sources of individual studies if they focused on the same PICO questions and were transparent in terms of their search methodology.

2.3. Study selection and data extraction

The search results (i.e. titles and abstracts) were screened and the full-text of potentially relevant articles was evaluated. The papers selected, following full-text evaluation, were analysed and all the relevant data were organised into an evidence summary. Within the evidence summary, the results were considered significant when the p -value was <0.05 . The quality of the body of evidence was evaluated by using predefined criteria developed by the GRADE (Grading of Recommendations Assessment, Development and Evaluation) working group.¹⁶ The determined 'level of evidence' reflects the likelihood that the estimates of effect are true and adequate to support a given recommendation.

2.4. Guideline development

A multidisciplinary guideline development panel was established, comprising of external experts from different fields (a child psychologist, a doctor in education, an educational adviser and medical doctors) and end users (school teachers from first/second grade; community and catholic schools; youth leaders). The assembled panel was able to provide expert guidance regarding the methodology of the identified papers and also the clinical content. The PICO questions and the evidence summary were sent for review to the external experts, who were asked to provide critical feedback of the search strategy used and the identified evidence.

During a meeting with the guideline development group, critical feedback on the best available scientific evidence was discussed. Additionally, practical experience and expert opinion was added to the evidence conclusions. The discussion culminated in a consensus and a set of evidence-based recommendations was generated. The panel subsequently assigned a grade (strong/weak) to the formulated recommendations (GRADE methodology).¹⁶ These grades of recommendation provide a judgement about the strength of a recommendation, balancing the quality of the evidence, the risks and benefits of an intervention, the preferences of the target group. Where no scientific evidence was available but there was consensus amongst members of the guideline panel, consensus-based recommendations were given. Such recommendations are called good practice points (GPPs) and were not graded.

Table 1
Characteristics of the selected studies on skills and performance.

Author, year	Study design	Country	Population	Comparison(s)/observation(s)
Reder et al., 2006 ¹⁸	Experimental: cluster RCT	USA	School students (14–18 years old)	AED skills of children after 3 different types of training: (1) computer training; (2) computer + practice; (3) video + demonstration + practice; and (4) no training (control)
Younas et al., 2006 ¹⁹	Experimental: non-RCT	UK	School students (13–16 years old)	AED use by children with or without (control) an 2 h AED training programme
Gundry et al., 1999 ²²	Experimental: non-RCT	USA	School students (11–12 years old)	Observation of AED use by untrained 6th grade children compared to professionals trained in medical emergencies (control)
Fleischhackl et al., 2009 ²¹	Observational: case series	Austria	School students (9–18 years old)	Observation of AED deployment by children 4 months after a 6 h CPR training
Lawson et al., 2002 ²⁰	Observational: before and after study	USA	School students (8–9 years old)	Observation of AED use by 3rd grade children before and after 2-min training

RCT, randomised controlled trial; studies are listed by year of publication and study design (experimental/observational).

3. Results

3.1. Evidence considering skills and performance

The systematic literature search identified one guideline from The American Heart Association (AHA).¹⁷ This guideline included 3 studies performed in the United States of America (USA) involving the use of an AED by school students (Table 1). The evidence review further identified two additional European reports, which resulted in 5 studies in total: one clustered randomised controlled trial (RCT), 2 non-RCT's and 2 observational studies. The characteristics of the included studies are shown in Table 1. The studies involved American or European populations and the mean age of the participants in the studies ranged from 8 to 18 years. The majority of the publications described utilised some form of training prior to the testing-phase.^{18–21} One study tested untrained children.²²

The use of an AED includes four important steps: (1) turn on the power-button, (2) place AED pads (the pads will analyse the heart rhythm), (3) clear bystanders away from the patient and (4) press the shock button. The included studies measured different outcomes, some were primarily focused on skills to perform all the steps in the right way (turn on the AED, place AED pads in correct position and press the shock button).^{18,19,21} Others focused on the

mean time for delivery of the first shock after following the spoken instructions.^{20–22} In three studies, an AED training to children was highly effective and resulted in high percentages of children handling an AED correctly.^{18,20,21} The study of Gundry et al. showed that sixth grade children without training are able to deliver a shock.²² In conclusion, both experimental and observational studies indicated that children can be taught to deploy an AED. Children as young as 8 years are able to deliver a shock to someone suffering from sudden cardiac arrest (Table 2).²⁰

3.2. Grading the evidence (skills and performance)

Both experimental studies and observational studies were included in the evidence summary. This has been done purposefully to review all available scientific evidence (regardless of study type or quality level) and to obtain a comprehensive result. The level of the body of evidence however depends on the number of studies with good methodological quality (in this review: experimental studies) and consistency of their reported results. An overview of the quality of the body of evidence was determined using the GRADE approach, taking into account limitations in study design, imprecision, inconsistency, indirectness and publication bias. The level of evidence was downgraded (–1) due to limitations in study

Table 2
Evidence summary: findings of the selected studies.

Outcome	Comparison(s)/observation	Measured outcome/effect size	Participants, <i>n</i>	Reference
Correct use of defibrillator (%)	AED use by trained children vs. by untrained children	26.5 vs. 4.0 OR 8.64 [1.02, 73.48] (<i>p</i> = 0.05)	59 (13–16 years old)	Younas et al. ¹⁹
	AED deployment of children after training (no control group)	93 (no effect size)	147 (9–18 years old)	Fleischhackl et al. ²¹
Correct AED key actions (%): 1. Turn on AED power 2. Place AED pads correctly on the body 3. Press shock button if indicated	AED skills of children after 3 different kinds of training: (1) computer training; (2) computer + practice; (3) video + demonstration + practice; and (4) no training (control)	(1) vs. (2) vs. (3) vs. (4) 2 days after training 1. 95/97/98/54 2. 81/91/92/32 3. 94/98/100/46 2 months after training 1. 98/97/97/68 2. 82/90/90/48 3. 95/98/98/63	779 (14–18 years old)	Reder et al. ¹⁸
Mean time for delivery of the first shock (s)	AED use by untrained children vs. by trained professionals	Mean ± SD 90 ± 14 vs. 67 ± 10 (<i>p</i> < 0.0001)	15 children (11–12 years old) vs. 22 professionals	Gundry et al. ²²
	AED use by trained children vs. by untrained children	Mean ± SD 59.3 ± 13.6 vs. 35.2 ± 6.0 (<i>p</i> = 0.001)	31 (8–9 years old)	Lawson et al. ²⁰
	AED deployment of children after training (no control group)	Median 69 IQR [55–84] (no effect size)	147 (9–18 years old)	Fleischhackl et al. ²¹

OR, odds ratio; IQR, interquartile range; SD, standard deviation.

Table 3

Characteristics of the selected studies on attitude and behaviour.

Author, year	Study design	Country	Population	Description
Taniguchi et al., 2008 ²⁴	Observational: survey	Japan	School students (12–18 years)	Survey to assess willingness to apply and operate an AED
Hubble et al., 2003 ²³	Observational: survey	USA	School students (13–19 years)	Survey to assess willingness to perform CPR and use AED

design in two experimental studies (lack of randomisation, allocation concealment and blinding).^{19,22} Additionally, the level was downgraded (–1) for imprecision, due to a low sample size in two studies^{19,22} and wide confidence intervals (calculated with the Review Manager 5 software) in the third study¹⁸. No further downgrading was needed for inconsistency and indirectness. A limited number of relevant studies were identified, which made it difficult to evaluate publication bias, therefore we did not downgrade the level. The overall body of evidence was graded as low quality, which means that further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.¹⁶

3.3. Evidence considering attitude and behaviour

The gathered evidence concerning behaviour and attitudes towards AED utilisation consisted of 2 surveys (population characteristics are described in Table 3).^{23,24} In both studies school students aged 12–19 years were tested. Taniguchi et al. (2008) surveyed more than 2000 high school students on their willingness to apply and operate an AED. A small proportion of the students (12%) indicated they would be willing to use an AED. Of these students, most (83%) knew how to use an AED and claimed they would definitely use it in case of a medical emergency. In a questionnaire-based study of Hubble et al., 32% of the students surveyed were willing to perform defibrillation with an AED. Students unwilling to use an AED had feared either of injuring the patient or fear of legal consequences of their actions. Remarkably, trained students were no more willing to perform defibrillation with an AED than untrained students.

3.4. Grading the evidence

The quality of the body of evidence was very low due to the fact that only surveys were included. The quality remained very low as no GRADE criteria was fulfilled to upgrade the evidence level.

3.5. Recommendations

Recommendations were developed based on the identified evidence, which was limited. A guideline panel discussed the findings and added their expert opinion to contextualise the collected data by considering the skills, attitudes and behaviour of children and young people of different ages. Where there was insufficient evidence for recommendations, good practice points (GPP) were formulated, based on expert consensus. The following recommendations and GPPs were formulated concerning AED-training for children and young people:

- It is important to teach the AED technique stepwise and reinforce previously gained knowledge before starting with the next step [GPP].
- In primary school, children can be taught to recognise the symbol of an AED and become aware of its function by listening to it. The application of an AED should only be taught after a complete CPR training [GPP].
- In secondary school, after their CPR training, and as a completion of this training, learn how to perform the four important steps of defibrillation with an AED [recommendation-strong].

- It is essential not to focus only on skills, but also on psychological issues. In emergency situations, bystanders will be confronted with barriers to helping. Making children aware of the fact that they will have to touch strange people when using an AED and underlining the safety of the AED-devices will help to overcome some of these barriers [recommendation-strong].
- All children should be taught to find help by an adult as soon as possible in emergency situations [GPP].
- Not all AEDs are alike, and demonstrating these differences may prevent children from becoming confused during an emergency [GPP].
- When the door of the cabinet housing the AED is opened, it sets off an alarm to alert nearby staff of the emergency. This action could be taught to children as a way to alert assistance and thereby potentially save a life [GPP].

3.6. Educational materials

Based upon the formulated recommendations and good practice points, the Red Cross Youth developed an education programme for every grade in primary and secondary school (Table 4), indicating the goals to achieve for knowledge, skills and attitudes. Further, structured educational materials were created focusing on the AED technique and general first aid. These structured guides contain exercises and activities designed to increase children's first aid knowledge and aim at helping school teachers and youth leaders in teaching first aid.

4. Discussion

This paper describes the development of evidence-based recommendations on the education of AED use in school children, i.e. recommendations based on evidence where available, complemented with good practice points. These recommendations served as the basis for the creation of a new set of guidelines, 'Defibrillation with an AED'. The process used to develop evidence-based guidelines was initiated with a systematic literature search in order to collect existing evidence. The few experimental studies identified by our search demonstrated that school children could be taught AED skills and, as such, they could be deployed to deal with sudden cardiac arrest.^{18,19,22} This finding was supported by two observational studies.^{20,21} The GRADE quality assessment however resulted in grading the experimental evidence as low quality, due to factors such as study design and small sample size. Two identified surveys examined the willingness of school children to apply and operate an AED.^{23,24} These surveys indicated that only a small portion of the questioned children would be willing to use an AED and concluded that training should employ techniques which encourage children to overcome barriers that may prevent them from assisting.

The guideline development panel considered the summarised evidence and discussed other factors to obtain a consensus when the available evidence was inadequate before evidence-based recommendations and good practice points were formulated. The other factors considered by the guideline development panel included didactical aspects along with psychological, physiological, medical and behavioural issues. During the panel meeting, the guideline development panel emphasised the importance of comprehensive and stepwise training of emergency skills. One of the

Table 4
AED education programme for every grade in primary and secondary school.

	Nursery school	Primary school			Secondary school		
		1st grade	2nd grade	3rd grade	1st grade	2nd grade	3rd grade
Knowledge	–	The pupils can explain why it is necessary to get help from an adult as quickly as possible in emergency situations.	The pupils: can identify an AED pictogram can explain the connection between opening an AED box and an alarm going off can explain that opening the door of the AED box will signal a call for help	The pupils: can explain that it is necessary to call 112 (even when the AED box is sounding an alarm) can explain the function of an AED in their own words by listening to the instructions	The pupils: can explain in what situation an AED apparatus must be used can indicate where to stick the electrodes can explain where not to stick the electrodes can explain what an AED machine does can explain that you need to keep at a distance when the victim is being assessed and when a shock is being administered can explain that an AED machine is safe to work with if it is properly used, and that it will never deliver a shock unless necessary can explain that the use of an AED machine is no substitute for resuscitation (but an add-on)		
Skills	–	The pupils can call on an adult for help can call 112	The pupils can open an AED box		The pupils can correctly use various types of AED machines can turn on the AED machine can correctly carry out the instructions for an AED machine: •can stick the electrodes in the right place •can keep bystanders at a distance from the victims •can press the shock button (if necessary)		
Attitudes	–	The pupils are: willing to provide help realise the importance of fetching an adult	The pupils realise the importance of opening an AED box	The pupils: realise the importance of calling 112 realise the importance of using an AED machine	The pupils: are prepared to use an AED machine are prepared to touch a stranger		

Tip, teach the AED technique in steps, and repeat each step before proceeding to the next one.

main challenges noted was the retention of the skills after training, and it was therefore determined that the gained knowledge should be regularly reinforced by performing emergency procedures, i.e. at school. Additionally, adequate information on 'helping behaviour' should be provided to reduce psychological stress in emergencies.

Implementation of the formulated recommendations requires proper teaching techniques and providing clear instructions for youth leaders and school staff. Using these evidence-based recommendations, the Belgian Red Cross-Flanders has developed school-age specific educational materials which could increase the awareness about life-threatening situations, whilst also preparing school students so that they may act as first responders and offer help in emergency situations. Implementation of this training package within the school system would maximise the number of people in the community who would be potentially able to administer defibrillation in cases of emergency.

5. Conclusion

In conclusion, the Belgian Red Cross-Flanders now provides a tool to make the implementation of AED training within schools easy. The Belgian Red Cross-Flanders advocates the incorporation of AED training into the school curriculum and hopes to convince policy makers and school staff of the benefits of AED training for school students.

Conflicts of interest statement

T.D., E.D.B., H.V., L.A., M.C. and K.V. are working for the Belgian Red Cross-Flanders. O.M., A.D., M.B. and C.C. do not have any conflicts of interest.

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